DESIGN OF BEAM DIAGNOSTICS FOR THE RCNP RING CYCLOTRON

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ABSTRACT

The beam diagnostics system of the ring cyclotron has been designed. The layout for each components were settled. All components will be manufactured in 1989.

1. INTRODUCTION

Beam diagnostics components for a ring cyclotron have been designed[1]. The layout, the specific design characteristics and the performance of the components have been fixed. The interface to the central computer to facilitate fast collection and treatment of a large amount of data has been designed[2].

2. LAYOUT

Layout of the beam diagnostic components forthe ring cyclotron are shown in Fig. 1.

2.1 Injection line

The beam from the AVF cyclotron, which is selected in momentum, in emittance and in phase, enters in the new cyclotron vault. There are two variable width slits (VSL-1,-2), three three-wire-profile monitors (TPM-1,-2,-3), one emittance monitor system(ESL+EPM) and one phase probe (P-INJ).

The beam shapes in transversal phase space are defined by VSL-1, and -2 to the eigenellipses of the beam in the ring cyclotron. The transverse beam shape and position are measured with the TPM-1, -2 and -3, while the beam emittance both for horizontal and for vertical planes are measured with single slit (ESL) and harp-type monitor (EPM) by rotating the system.

Just in front of the valley chamber of the ring cyclotron, TPM-4, TV-monitor (TVM-INJ) and the beam stop (BS-INJ) are all housed in the one unit of a diagnostic chamber. The beam is investigated in size and position once more with the TPM and TVM-INJ, while the beam is interrupted by BS-INJ. The actual phase of the incoming beam form the cyclotron relative to the acceleration r.f., would be measured by the no-intercepting capacitive pick-up (P-INJ).

After the beam stop, the beam is injected into the valley, where there are several accelerator components such as electrostatic extraction or injection channels (EEC-1,-2 and EIC-1,-2). To find the horizontal beam position at the end of the valley, there is a fast rotary scanner (RPM-INJ) driven by a super-sonic motor in that chamber. Thus, during the beam transport through three dipole (BM-2,-3,-4) and one quadrupole (QM) magnets, the beam is directed only by monitoring the current with buffer slits (SL-1,- 2,-3,-4) located at the entrance of these elements and with one profile monitor (TPM- 5).

2.2 Injection Orbit

The beam arrives in front of the first magnetic inflection channel (MIC- 1), where the beam should be matched for the eigenellipses of the accelerator orbit. To define the beam size completely, horizontal and vertical beam width are reshaped both with a horizontally valuable width slit (VSL-INJ) and with a vertically fixed width slit (FSL-INJ). These are combined with a profile monitor (TPM-INJ-1,-2) as shown in Fig. 2. Then, the beam passes through two magnetic inflection channels. Buffer slits are also used as diagnostic elements (SL-5 $\sim$ 12) at these entrances or exits.

In addition, radial beam profile, correlation between the beam phase and the beam radius are measured with a radially moved single wire (PPEN-INJ) located between EIC-1 and EIC-2.

2.3 Acceleration Orbit

Inside the valley chamber, there are three types of beam diagnostics devices such as main probe (M P), phase probe (PP-ACC) and three additional beam stops (BS-ACC-2,-3,-4).

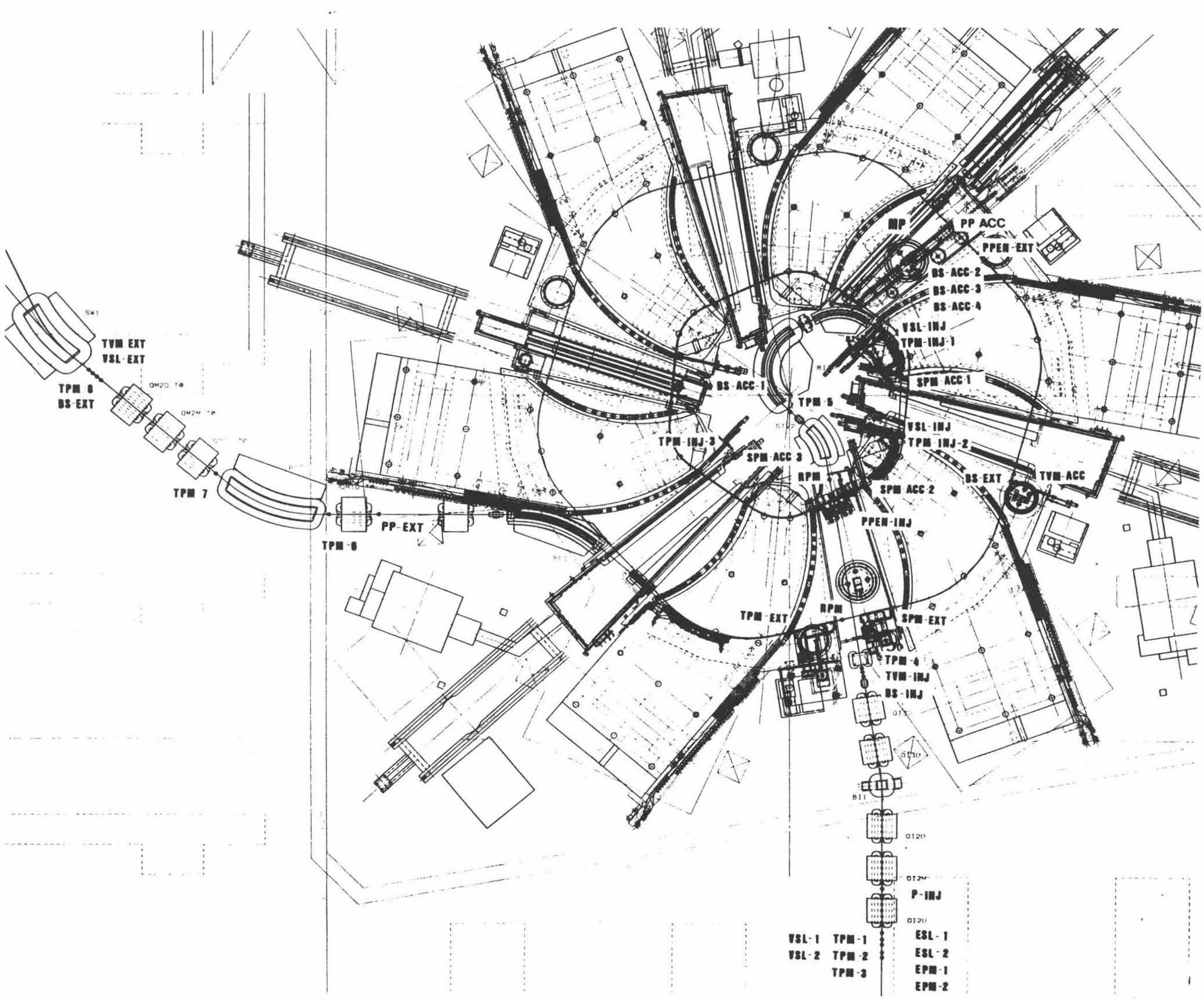

Fig. 1. The layout of the beam diagnostics devices.

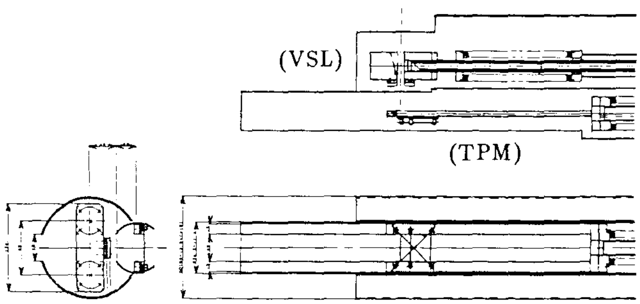

Fig. 2. Three-wire Profile monitor (TPM) and horizontal variable width slit (VSL) located at the inlet of the first magnetic inflection channel (MIC-1).

2.4 Extraction Orbit

Along the extraction orbit, several types of beam diagnostics are located; they are single wire energy-phase monitor (PPEN-EXT), TV-monitor (TVM-ACC), beam stop (BS-ACC-5), single-wire profile monitor (SPM-EXT), a fast rotary scanner (RPM-EXT), and three-wire profile monitor (TPM-EXT). The TPM and the RPM will be used to measure the orbit separation and centering, while the SPM set in front of the 1st extraction channel will be used to see whether the separation is sufficient for the septum of its channel. As mentioned before, buffer slits (SL-13 ~ 20) for all extraction elements are helpful to protect these elements and to guide the beam correctly.

The extracted beam is finally monitored with three TPM(TPM-6, -7, -8), variable width slits (VSL-EXT), phase probe (PP-EXT) and T.V.-monitor (TVM-EXT).

Two TPMs combined with quadrupole magnets are useful to measure the transverse emittance of the beam by the GSI method.

3. ELEMENTS OF DIAGNOSTIC SYSTEM

3.1 Main Probe (MP)

A main probe measure the current and the transverse shape of the beam through injection to extraction radius. It consists of a three-wire tomography head of three thin wire (W) and indirectly cooled beam stop.[3] The probe can be adjusted for its head to be directed to the tangential of the beam orbit at any radius. The driving spread are 20 mm/sec and 200 mm/sec for measurement and without measurement respectively.

3.2 Beam Stop (BS)

There are two types of beam stop; differential type in injection or extraction orbit, up and down type in accelerator chamber. These are set in the radius of r=2000, 2395, 2872, 3350 and 4000 mm respectively. Two differential type beamstops at minimum and maximum radii can be moved in radial direction about a few ten mm. And other three stops can be moved pneumatically up and down. All heads are thick enough to intercept the beam at each radius. The total beam current intercepted can be measured. These stops are prepared to optimize the accelerator condition without serious activation of the accelerator components other than these beam stops.

3.3 Phase Probe (PP-ACC)

The beam phases relative to the accelerator r.f. phase are measured with eight capacitive phase detectors, which are separated by 300 mm each other on same carriage. It is installed along the line at the same azimuthal interval as the each accelerating gap between the sectors. They cover the full radius continuously by driving the carriage. One unit of the detector has two electrodes (upper and lower).

The beam phases are measured with sampling method. Sampling pulse and horizontal trigger pulse are generated by circuits as shown in Fig. 3. The sampled signals are digitally processed with a digital oscilloscope to interface the computer control system.

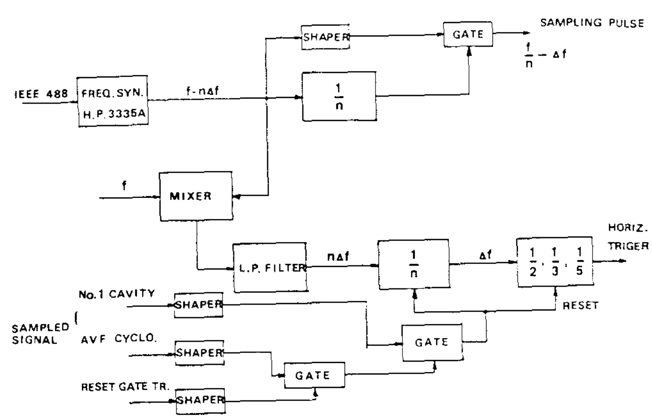

Fig. 3. Block diagram of sampling pulse circuits and horizontal trigger pulse circuits for digital oscilloscope.

3.4 Energy-Phase Probe (PPEN-INJ,EXT)

The energy-phase probe is prepared to measure the time structure of the beam at various radial position for the injected orbit and to measure the correlation of the beam phase and beam radius (energy)[4]. The same device is installed in the extraction orbit to observe such correlation of the beam on the final few turns. Thin single wire target is driven radially. Scattered particle would be detected by a plastic scintillator. The time interval between the particle signal and r.f. of the accelerator is measured with time to pulse height converter and the signals are converted digitally. Two dimensional analysis for the time interval and the radius is expected.

4. MISCELLANEOUS

Besides these, we have tested several components which would be exactly applicable to the diagnostic devices.
i) In order to move the single wire up and down in the magnet chamber, we will use ferrofluidic sealing for the rotating shaft. For this purpose, we examined two types of ferrofluidic sealing in the presence of the strong magnetic field. One of them showed the clear defect; the vacuum leak started at the magnetic field about 100 Gauss. The other was stably operated at more than 600 Gauss as shown in Fig. 4.
ii) The supersonic motor without water cooling can be used at the magnetic field of 1.6kG inside the vacuum chamber.

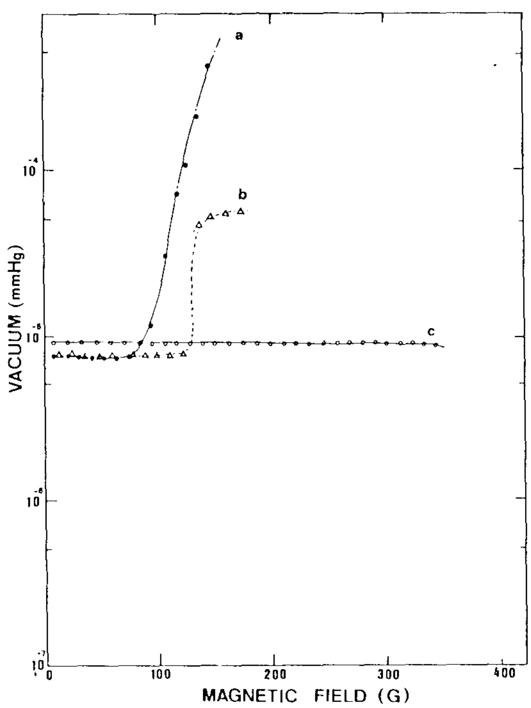

Fig. 4. Vacuum leakage of the ferrofluidic sealings caused by magnetic field.

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